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FEDERAL COMMUNICATIONS COMMISSION
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May 14, 1996

Richard M. Smith, Chief
Federal Communications Commission
Office of Engineering and Technology
2000 M Street, N.W., Suite 480
Washington, D.C. 20554

Dear Dick:

This is to follow-up my discussion with your secretary earlier today, and to confirm our meeting on Monday, May 20, 1996 at 3:00 p.m. in your offices. Attending the meeting with me will be Wayne Love of Fusion Lighting Inc. The purpose of our meeting will be to discuss Fusion's urgent need for a waiver of the Part 18 conducted emission limits for a new microwave lighting technology that is planned for commercial introduction to end-users in the next couple of months.

Please let me know at your earliest convenience if there is any information you would like to have in advance of our meeting. I look forward to seeing you on the 20th.

Very truly yours,

Terry G. Mahn

TGM/smw
cc: Julius Knapp, Chief
Equipment Authorization Division
L. Art Wall, Chief
Commission Services Branch
Richard Engelman, Chief
Standards Development Branch
John Reed
Technical Rules Branch
Dr. Robert Cleveland
Office of Engineering & Technology
Wayne Love
Fusion Lighting

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FusionLighting

Fact Sheet

The re-lighting of the Space Hall and the plaza of the Forrestal Building demonstrates two new and exciting lighting technologies — the development of the electrodeless sulfur lamp and the efficient distribution of light through light pipes. Both hold the promise of significant near-term energy saving.

The Department of Energy and the Lawrence Berkeley Laboratory are supporting the ongoing development and application of each of these new technologies.

The Environmental Protection Agency and NASA are also supporting specific aspects of the development of the electrodeless sulfur lamp.

Smithsonian National Air and Space Museum

Three 90 foot long pipes, each lit at one end by a single electrodeless sulfur lamp, have replaced 94 conventional lamps to light the Space Hall.

The results:

- Light levels have increased by a factor of three.
- Energy usage has been cut by a fourth.
- Unwanted UV has been cut in half.

Other advantages:

- Installation and retrofit costs of the sulfur lamp and light pipe combination were less than half the costs of a conventional lighting upgrade project.
- The light pipe significantly reduces maintenance costs. With the new system, the lamps are positioned for easy maintenance while the light pipe distributes the light throughout the exhibition area.

The Forrestal Building — Headquarters of the United States Department of Energy

A single 240 foot long light pipe, powered at each end by a single electrodeless sulfur lamp, has replaced 240 175 watt conventional HID lamps to light the entrance and roadway outside the building.

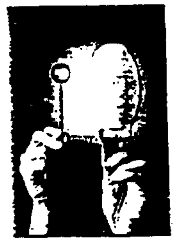
The results:

- Light levels have increased by a factor of four
- Energy usage has been cut by two-thirds

Other advantages:

- The optical design of the light pipe provides a broad-beam. high lumen distribution of light along the pedestrian walkways while illuminating the roadway with a narrow beam of non-glare light.
- This is the longest continuous light pipe of its type ever constructed.

About the lamps



The sulfur lamp (left) was invented, designed, and built by Fusion Lighting, Inc. of Rockville, Maryland. The unique technology is protected by a variety of patents and patent applications in the U.S. and other countries.

These are demonstration lamps. Commercial versions of the high-powered electrodeless sulfur lamp are being developed by Fusion Lighting.

The light emitted from one of these sulfur bulbs is equal to over 250 standard, 100 watt incandescent lamps.

The bulbs are electrodeless, meaning that there are no wires connected to the bulb. There is no filament or metal electrode within the bulb.

Light is generated by heating sulfur with microwave energy, identical to that of home microwave ovens.

The spectra of the sulfur light contains all colors of the rainbow, closely matching that of the sun. but with very little heat or ultraviolet in the beam.

Each bulb, about the size of a golf ball, runs at 5.900 watts producing 450,000 lumens with a CRI of over 80.

There is no mercury used in the bulbs.

About the light pipes

The light pipes were invented, designed, and built by A.L. Whitehead, Ltd., Vancouver, Canada.

The reflector material used in the light pipe is manufactured and sold by 3M, and is protected by various patents.

The light guides are ten inches in diameter and are fabricated in ten-foot sections.

The light pipes are of all-plastic construction. Each ten-foot section weighs approximately 30 pounds.

About Fusion Lighting, Inc.

The Company has 28 people working on developing innovative new lighting products based on the technology of the electrodeless sulfur lamps.

It was started in 1993 as a spin-off from Fusion Systems Corporation, a NASDAQ-listed capital equipment maker and the pioneer in microwave lamp technology.

FUSION LIGHTING, INC.

301 251 0300 • 7524 Standish Place, Rockville, Maryland 20855 USA • FAX 301 926 7258

FusionLighting

NEWS

FUSION LIGHTING ANNOUNCES IMPROVED SOLAR 1000™ SULFUR LAMP

Orlando, Florida, April 29, 1995: Fusion Lighting today announced the development and successful testing of a new Solar 1000™ sulfur lamp. The new microwave, electrodeless lamp is much smaller and simpler than the sulfur lamp demonstrated last October in Washington, DC, and currently in use in the Space Hall of the Smithsonian's National Air and Space Museum and in other test locations in the U.S. and abroad. The lamp developed by Fusion Lighting is a prototype lamp and commercial versions are not available. The prototype lamp was exhibited in conjunction with Fusion Lighting's nomination for the 1995 Discover Magazine Awards for Technological Innovation, and was demonstrated for the first time by Hazel O'Leary, Secretary of the U.S. Department of Energy (DOE), who was in attendance at the award's ceremony. The announcement of the new Solar 1000™ was made by Michael Ury, Vice President, Research and Development, for Fusion Lighting.

The Solar 1000™, which was developed with support from the DOE, NASA, and the EPA, uses microwave energy similar to that found in a home microwave to excite sulfur gas in a small glass bulb (the prototype bulb is only 40 mm — 1.5" in diameter). The results are light output or lumens equal to 75 standard 100 watt incandescent light bulbs. Of particular interest to the DOE was the reported system's efficiency which was tested at 98 lumens per watt as compared with 18 lumens per watt typically found in incandescent lamps. According to Mr. Ury of Fusion Lighting, "The energy savings of these or similar sulfur lamps in public buildings, parks, parking lots, malls, and large warehouses or open spaces could be enormous. In addition, the full-sunlight spectra offers many potential benefits for users and the absence of mercury in the bulb virtually eliminates this environmental concern."

* * *

Fusion Lighting, Inc., is a private, high-technology firm located in Rockville, Maryland. The Company is noted for its scientific research and development, particularly in the areas of lighting and of energy-efficient light-delivery systems that will have broad applications and uses in exterior lights of buildings, street lamps, shopping malls, stadiums, and parking lots.

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FusionLighting

NEWS

For Immediate Release

FUSION LIGHTING RECEIVES DISCOVER MAGAZINE AWARD

Rockville, Maryland, May 2, 1995: Fusion Lighting, Inc. announced today that it has received the prestigious Discover Award for Technological Innovation in the environment category for its development of the sulfur lamp. Michael Ury, Vice President for Engineering and Research and Development for Fusion Lighting, Inc., who headed the team that first discovered the sulfur lamp, received the award on April 29 in a ceremony at Disney's Epcot '95 in Florida. The award, sponsored by *Discover Magazine* and the Walt Disney Company, is given annually to the individual and firm that discovers a new technology with the potential to be of the greatest public good. Present also at the awards were Ms. Hazel O'Leary, Secretary of the U.S. Department of Energy, and Mr. Daniel Tessler, Chairman of the Board of Fusion Lighting, Inc. The Department of Energy has actively supported the development of the sulfur lamp and the earliest applications of the new lighting system.

In a press release announcing the finalists for the award, *Discover Magazine* said, "The Discover Awards recognize breakthrough technologies and honor the men and women whose creative genius improves the quality of everyday life." Fusion Lighting was selected from among thousands of nominees as a finalist in the environment category. The awards also recognize technological innovation in six other categories including, aerospace, automotive, computer hardware, computer software, sight, and sound.

In accepting the award, Mr. Ury of Fusion Lighting said, "I am pleased to accept this award on behalf of everyone who has worked so long and hard to establish the great potential for this new technology. Our developmental tasks were made easier by the active support of the Department of Energy, particularly Dr. Lee Anderson of the Office of Energy Efficiency and Renewable Energy." Ury continued, "We believe we have just scratched the surface of the hundreds of important uses that will come from this new lighting technology. We have had interest from around the world — from architects, lighting designers, scientists and industrial and commercial users. We believe the potential for this new lighting system will grow as additional research and testing is completed."

(over)

FUSION LIGHTING, INC.
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NEWS

Mr. Dan Tessler, Chairman of the Board of Fusion Lighting said, "We are encouraged by the significant interest from many diverse sources who see the potential in this new lighting system. We are pleased that *Discover Magazine* also sees the importance of this scientific breakthrough and that they share with us considerable optimism about its future."

The event was also noteworthy because Fusion Lighting exhibited for the first time in public a prototype of its new Solar 1000™ lamp. The Solar 1000™ will be the first commercial product using the revolutionary, energy efficient technology. The first commercial units are expected to be available beginning in 1996. The use of sulfur lamps will provide an unprecedented combination of energy efficiency, long life and maintenance-free lighting. Commercial users are expected to be particularly impressed with the quality of the light and absence of mercury which means they will not have the same environmental concerns that have characterized the disposal of other high-efficiency lamps.

Because of its very high light output, the Solar 1000™ is expected to be used initially in factories, shopping malls and retail spaces and in large indoor and outdoor public spaces. An earlier version of the sulfur lamp technology was demonstrated in October, 1994, in a special lighting event at the U.S. Department of Energy's Forrestal Building and at the Smithsonian's National Air and Space Museum in Washington, DC. Both sulfur lamp systems remain operational and can be seen by the public. Fusion's sulfur lamp will also be part of the Discover Awards Showcase at the Innovations Pavilion at Epcot '95.

* * *

Fusion Lighting, Inc. is a private, high-technology firm located in Rockville, Maryland. The Company is actively engaged in developing the sulfur lamp technology through a family of unique products aimed at different markets.

FusionLighting

NEWS

POWERFUL, NEW ENERGY-EFFICIENT LIGHT SOURCE TO LIGHT FORRESTAL BUILDING, AND AIR AND SPACE MUSEUM

Washington, DC, October 20, 1994: Fusion Lighting, Inc. today announced the development of a new, highly-efficient light source. This new light source has been installed in the plaza of the Forrestal Building, the headquarters of the U.S. Department of Energy, and the large Space Hall of the Smithsonian's National Air and Space Museum, both on the Mall in Washington. Ceremonies to inaugurate the first use of the new system are scheduled to begin at the Forrestal Building in Washington, DC, at 7:00 pm, October 20. Immediately following, a similar lighting ceremony will be held at the Air and Space Museum. The announcement was made jointly by Christine Ervin, Assistant Secretary of the Department of Energy, and by Les Levine, President of Fusion Lighting.

The new light source, designed and built by Fusion Lighting, represents a unique scientific breakthrough — the use of sulfur gas excited by microwave energy to generate light. The result is an extremely bright and highly-efficient white light that closely matches the properties of sunlight. The lighting of the Forrestal Building and the Air and Space Museum are among the first practical uses of this new light source technology. In these two locations, a light pipe, designed and built by A. L. Whitehead, Ltd. of Vancouver, Canada, collects focused light from a high-power sulfur lamp and distributes it evenly over large areas.

The sulfur lamp was invented three years ago by scientists and engineers now working at Fusion Lighting, a Rockville, Maryland, high-technology firm. They discovered that sulfur, excited by microwave energy, could be used to produce a very bright, high-quality light.

According to Michael Ury, Vice President of Fusion Lighting and one of the inventors, "The benefits of this new light source are just beginning to be realized. To be sure, there is a great deal more work to be done and some problems need to be overcome, but the future is indeed bright. We are grateful for the confidence in our technology and for the cooperation we have received from the Department of Energy and from the Smithsonian Institution. We appreciate being allowed to install these new systems and to demonstrate so publicly and so conclusively, the benefits of our lamps at their facilities. We hope this will encourage additional interest and support for additional applications both in the United States and abroad."

Additional information on the sulfur lamp and these two demonstration projects can be obtained by contacting Fusion Lighting.

SCIENCE
ENGINEERING

A New Kind of Illumination That Burns Brightly, but Not Out

By Curt Suplee
Washington Post Staff Writer

The Department of Energy is looking at the future in a whole new light.

Forget incandescent bulbs, fluorescent tubes and even metal halide lamps, says Lee Anderson, DOE's program manager for lighting research. Much of tomorrow's illumination, he and others believe, will come from electrodeless devices that have no parts to burn out—and that produce the kind of intensely white light suitable to the increasingly detailed work done in high-tech industry. "American workers need better lighting," Anderson said, "not only for attention to detail in microcircuits and small mechanisms, but in quality control."

The Prototype

The brightest prospect of that kind is a revolutionary prototype bulb developed by Fusion Lighting of Rockville in conjunction with DOE: A tiny closed quartz sphere containing argon gas and a pinch of elemental sulfur. When zapped with ordinary kitchen-grade microwaves, the bulb gives off intensely bright and relatively cool rays that are remarkably similar to sunlight.

In unveiling test installations of the device last week at DOE headquarters and the National Air and Space Museum, Assistant Energy Secretary Christine Ervin called it "a major technological breakthrough."

For all its novelty, however, the sulfur bulb still makes light the old-fashioned way: by temporarily altering the energy level of electrons in atoms. Electrons can occupy any of a number of different energy states while orbiting the atom's nucleus. Raising an electron to a higher level takes additional energy, just as moving a worker from her normal office on the second floor to temporary quarters on the fifth floor requires power from the elevator or the muscles.

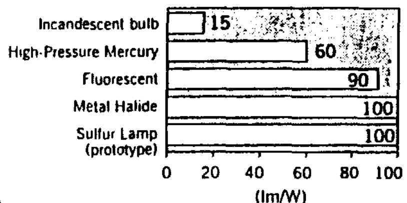
Blasting an atom with extra energy from outside (heat in an incandescent lamp, solar particles in the northern lights, microwaves in the new sulfur bulb) will cause electrons to pop up to higher energy levels. This is an unnatural condition, and they soon drop back to their normal states. As they do, they shed their

THE SULFUR LAMP

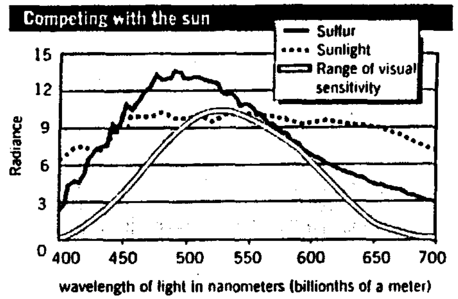
Last week, the Department of Energy and a company called Fusion Lighting Inc. announced the development of a new device called the Sulfur Lamp. It produces bright white light by exposing a sealed quartz bulb containing argon gas and a small amount of sulfur to microwave radiation. In test installations at the DOE's Forrestal Building headquarters and the National Air and Space Museum, the bulb is coupled with 10-inch diameter "light pipes" that carry the rays over long distance.

Comparing lamp efficiency

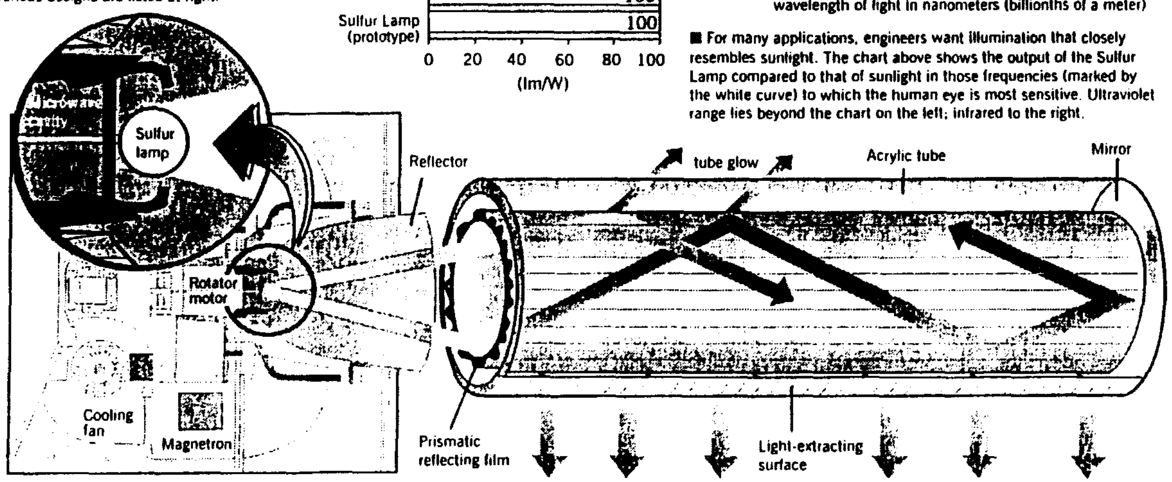
■ Different kinds of lamps can be compared by measuring the number of lumens (a standard unit of light flow) they emit per watt of energy use. Some approximate averages for various designs are listed at right.



Competing with the sun



■ For many applications, engineers want illumination that closely resembles sunlight. The chart above shows the output of the Sulfur Lamp compared to that of sunlight in those frequencies (marked by the white curve) to which the human eye is most sensitive. Ultraviolet range lies beyond the chart on the left; infrared to the right.



SOURCES: DOE, Fusion Lighting Inc., McGraw-Hill Encyclopedia of Science & Technology

BY JOHN ANDERSON—THE WASHINGTON POST

excess energy in the form of photons: the individual units of light.

The color (wavelength) of the light depends on the kind of atom or molecule that is excited and the way its electrons are arranged. Sticking a bit of common salt—sodium chloride—in a flame, for example, will turn the flame yellow. Spraying the Earth's upper atmosphere with electrons and protons blown off the sun (which is what happens in the aurora borealis) will cause nitrogen to glow violet and blue, and oxygen to flash crimson or whitish-green. Running an electrical current through a tube of neon turns it bright red.

A wide variety of energy sources can be used to produce this phenomenon, including fire. When a candle is lit, the carbon and hydrogen atoms in the wax are vaporized and combine in rapid combustion with oxygen in the air. The violent energy of the reaction excites electrons, which give off photons. A less messy way to achieve the same effect, Thomas Edison found, was to run a current through a wire filament and let the heat generated by electrical resistance turn the filament incandescent. In that case, the electrons of a tungsten wire are excited to the point at which they emit the familiar warm yellow-red illumination.

No Need for Heat

But the source does not have to be incandescent, or even hot. In a fluorescent light, for example, small amounts of mercury are suspended in a cold gas. As the current passes down the tube, it ionizes the gas, which in turn imparts energy to the mercury, whose electrons give off photons in the ultraviolet range. The UV rays then strike a special coating of phosphors on the inside of the tube. When excited by UV radiation, the phosphors (usually magnesium, zinc and cadmium compounds) shed their excess energy in the form of visible light.

Sodium-vapor or mercury-vapor outdoor lights work in a similar, though higher-intensity, fashion. In metal halide lamps—popular for lighting sports arenas and commercial interiors—an electric arc is run through a quartz tube containing a sophisticated mix of metals such as sodium, indium, thallium, scandium or tin compounded with iodine. The combination of emissions from these metals produces a pleasing, near-white light.

'Noble Gases'

In each case, the elements of the lamp have to be kept in an oxygen-free environment so that they don't burn. The environment of choice has been one of the "noble gases"—helium, neon, argon, krypton or xenon—that are notoriously unreactive. A frequent choice is argon, a completely inert element that seeps from below the Earth's surface and makes up about 1 percent of air.

In the version of the Fusion Lighting lamp used to light a 240-foot-long area outside DOE's Forrestal Building, a bulb about the size of a golf ball is filled with argon at one-tenth atmospheric pressure and approximately the amount of sulfur in a safety match. When the mix is irradiated with electromagnetic waves at 2.4 billion cycles per second (about what the average home microwave oven puts out), the argon heats up and vaporizes the sulfur, which forms into two-atom molecules.

As the molecules' excited electrons drop back to their ground states, the Fusion researchers found, they generate an unusually large quantity of photons in an uncommonly wide variety of types. The result is a spectrum, or range of wavelengths, very close to those in white sunlight, which is the combination of all colors generated by incandescence on the sun's surface.

The sulfur bulb gets so hot that it has to be rotated at 300 to 600 revolutions per minute to prevent the quartz from melting, which it would do "in about 2 seconds" if uncooled, says Fusion Lighting vice president Michael Ury. (Early prototypes also required two fans per bulb; later versions have eliminated that need.)

Lacking Electrodes

One of the bulb's chief advantages is that is has no electrodes. Eventually, DOE's Anderson said, any electrode will break down or burn out, and multipart tubes often develop flaws in their glass-to-metal seals; consequently, the amount of light emitted declines over time. In general, Anderson believes, "electrodeless lighting is the thing of the future."

And in the case of the sulfur bulb, it is also, ironically, a thing of the past: Perhaps the first electric lamp—as constructed in 1650 by German physicist Otto von Guericke—was based on sulfur. As Michael Allaby writes in "Fire: The Vital Source of Energy": "When a globe filled with sulfur was rotated fast and he held his hand against it, the sulfur glowed. He did not know it, but the friction of his hand was imparting an electric charge to the glass, which was exciting electrons in the sulfur atoms. In effect, he had discovered electric light."

BUSINESS TECHNOLOGY

A Light to Replace Hundreds of Bulbs

A new type of energy-efficient, long-life lighting developed by a Maryland company with support from the Energy Department may allow the replacement of hundreds of floodlight bulbs with just a few of the new units.

The technology uses microwave energy to produce white light similar to that emitted by the sun. The microwaves excite the element sulfur, which is combined with an inert gas in a golf-ball-sized bulb. Unlike conventional light bulbs, there are no electrodes inside to burn out, the most common form of lamp failure.

The bulbs have been combined with plastic "light pipes" for testing at two installations in Washington, the Forrestal Building, which is headquarters for the Energy Department, and the Smithsonian Institution's Air and Space Museum.

In each installation, light from the sulfur bulb is projected by a reflector into long plastic pipes lined with a semireflective film. With either a mirror or a second bulb at the far end, the light reflects back and forth as it goes along the pipe, with some of it leaking through the semireflective film to illuminate the surrounding area.

At the Forrestal Building, a single light pipe 10 inches in diameter and 240 feet long, with a sulfur bulb at each end, has replaced 240 individual 175-watt high-intensity lamps to illuminate the entrance and the nearby roadway. Energy Department officials say the pipe gives off four times as much light as the series of bulbs it replaced, but consumes only one-third the electricity.

The Federal officials say that the sulfur in the bulb does not wear out and that the life of the units is limited only by the microwave generators, which last 10,000 to 15,000 hours. They said the cost of the light pipes for the two test installations was less than half the cost of the bulbs they replaced.

The sulfur lamp was developed by Fusion Lighting of Rockville, Md. The light pipe was invented by A.L. Whitehead Ltd. of Vancouver, using plastic reflector films sold by Minnesota Mining and Manufacturing. Fusion Lighting expects to have a commercial product on the market next year.

JOHN HOLUSHA

The New York Times

The new lighting source at the Energy Department uses microwave energy to produce white light similar to that emitted by the sun.

Energy Dept. Brings Dazzling Bulb to Light

By Curt Suplee
Washington Post Staff Writer

The Department of Energy yesterday unveiled what it called "a revolutionary 21st century" lighting system that uses a bulb of sulfur bombarded by microwaves to produce bright illumination resembling sunlight—and does so at a fraction of the cost of many conventional systems.

The prototype lamp, invented by a Rockville start-up company called Fusion Lighting Inc. and developed under contract to DOE, consists of a closed quartz sphere filled with an inert gas and a tiny amount of sulfur. One golf-ball-sized sulfur bulb, when irradiated by the kind of compact microwave generator found in ordinary kitchen ovens, puts out as much light as hundreds of high-intensity mercury vapor lamps.

The result is "a major technological breakthrough in lighting," said Christine Ervin, DOE's assistant secretary for energy efficiency.

Commercial products are not expected until sometime in 1995, and the first applications are likely to be in lighting extensive outdoor and indoor spaces such as shopping centers, aircraft hangars and factories. Illuminating such areas now costs the United States approximately $8 billion per year, Ervin said. Use of the bulb in office or residential lighting is unlikely in the near future and would require much further research.

DEPARTMENT OF ENERGY

The sulfur lamp produces as much light as hundreds of high-intensity mercury vapor lamps—at a fraction of the cost.

The first large-scale use of the lamp is being tested at the DOE's Forrestal Building headquarters in Washington. Two of the golf-ball-sized bulbs—one shining into

See LIGHT, A22, Col. 1

Energy Dept. Is Aglow About New Bulb

LIGHT, From A1

each end of a 240-foot, 10-inch-in-diameter reflective plastic "light pipe"—have been installed in the building's entry area, which was previously lit by 240 175-watt mercury lamps. The new system, which uses less than 12,000 watts, produces four times as much light at approximately one-third the cost.

A similar test is being conducted at the National Air and Space Museum, where three 90-foot light pipes powered by sulfur bulbs have replaced 94 separate conventional fixtures in one display area. The test units put out three times more light at a 25 percent saving in cost, Ervin said.

Also important, said Frank A. Florentine, the museum's lighting director, is that the sulfur bulb emits much less ultraviolet light than traditional [illegible] nearly everything" in the exhibits, he said—notably uniforms and space suits, some of which have already had to be replaced or renovated because they bleached or dried out under the existing lights.

Unlike most other high-intensity lighting sources, the sulfur lamp has no electrodes, which are "the principal limitation to achieving long life in conventional bulbs," Ervin said. And because there is no evidence that the sulfur reacts chemically to degrade the quartz, the lamp may not wear out for years. "We just don't know how long they'll last," said Fusion Lighting Vice President Kent Kipling.

The DOE expects initial lifetimes of 10,000 to 20,000 hours. That is comparable to the kind of high-intensity lamps commonly used for street lighting; but those frequently lose as much as half their light output by the end of their life spans. The developers expect the sulfur bulb to sustain nearly peak output throughout its life.

Others are less certain. "I'd be anxious to see independent test data," said Bob Davis, technology group leader at the Lighting Research Center of Rensselaer Polytechnic Institute in Troy, N.Y.

Color is a major problem with many existing lamp designs. Sodium-vapor lamps are very energy-efficient, but their light is a harsh yellow. Mercury-vapor lamps put out blue-green illumination that makes red things look brown or black, although their bulbs can be coated with chemicals to improve the hue. (Metal halide lamps, currently used to light sports stadiums, industrial interiors and the like, produce nearly white light. But they have electrodes.)

The electrodeless sulfur bulb, however, emits a white light that is optically very similar to sunlight. In initial agricultural tests, Kipling said, "plants behave as if they're seeing sunlight." NASA has a two-year contract with the company to develop lights for growing plants in space.

Lee Anderson, DOE's project manager for lighting research, said that the quality of light will be especially important to the increasingly detailed work done in U.S. high-tech factories.

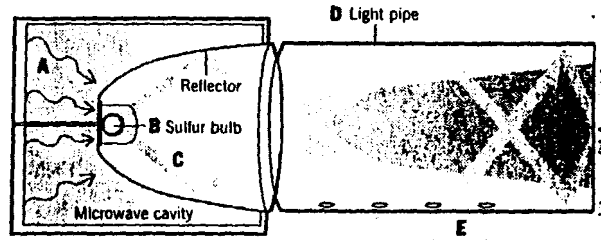
Privately held Fusion Lighting is a spinoff of Fusion Systems Corp. of Rockville. Three years ago, researchers there substituted sulfur for mercury in a bulb and discovered that it generated a bright white light.

Anderson went to observe the experiment, got the department interested in a development plan and arranged for technical help from the Lawrence Berkeley Laboratory in California. Meanwhile, Fusion Lighting realized that the sulfur bulb's relatively low-temperature output would work well with the kind of light pipe invented by A.L. Whitehead of Vancouver and manufactured by 3M.

"One of the missing links with that technology," said RPI's Davis, "has been a high-intensity source small enough to put in a reflector" that could be mounted on the end of the pipes. "The most exciting potential of this lamp is in its use for distributed or remote lighting where the light source can be located at some distance away."

HOW IT WORKS

Microwaves **(A)** *bombard a mixture of sulfur and argon gas inside a golf-ball-sized bulb* **(B)**.

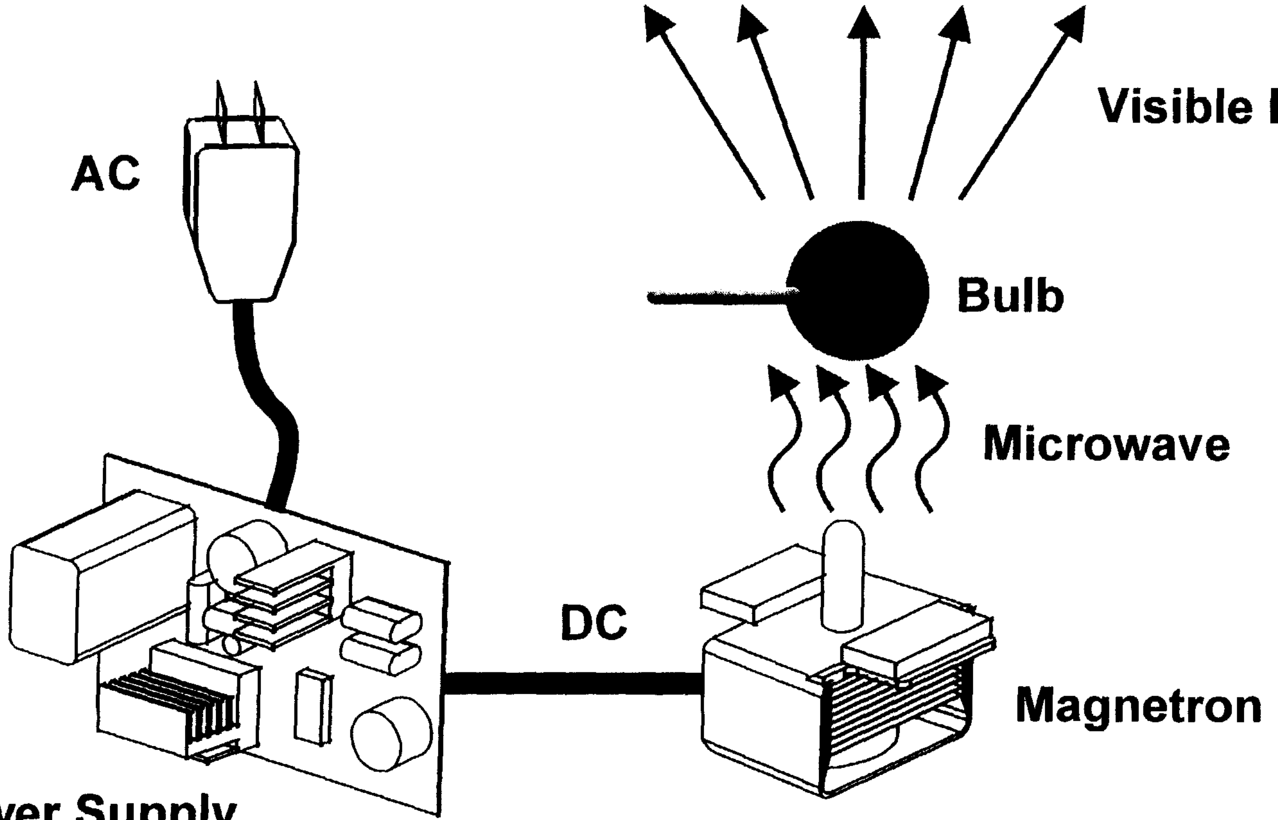


Electrons in the sulfur molecule, energized by the heated gas, emit bright light **(C)** which is directed by a reflector down a long "light pipe" **(D)**. A film totally reflects the rays, but some escape through holes to provide light **(E)**.

BY JOHN ANDERSON—THE WASHINGTON POST

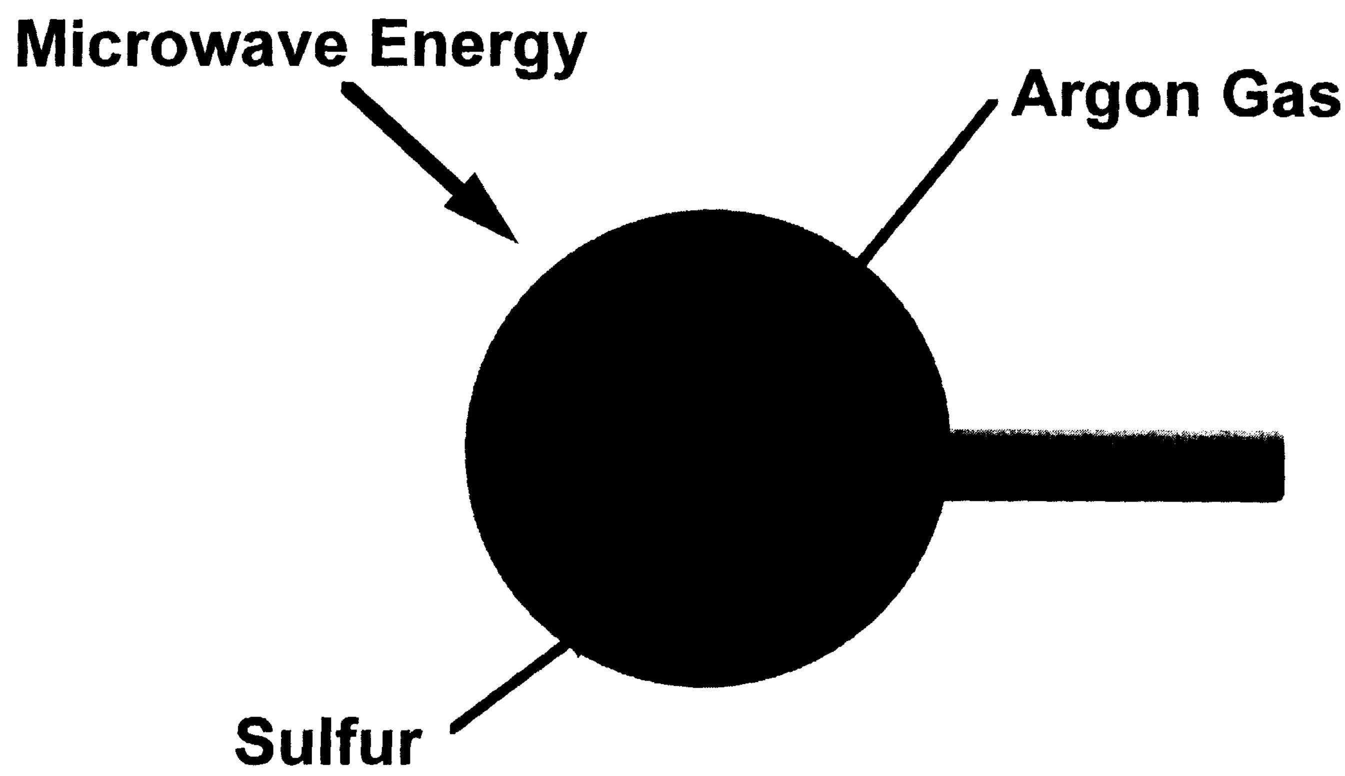
Fusion Lighting, Inc.

Technology



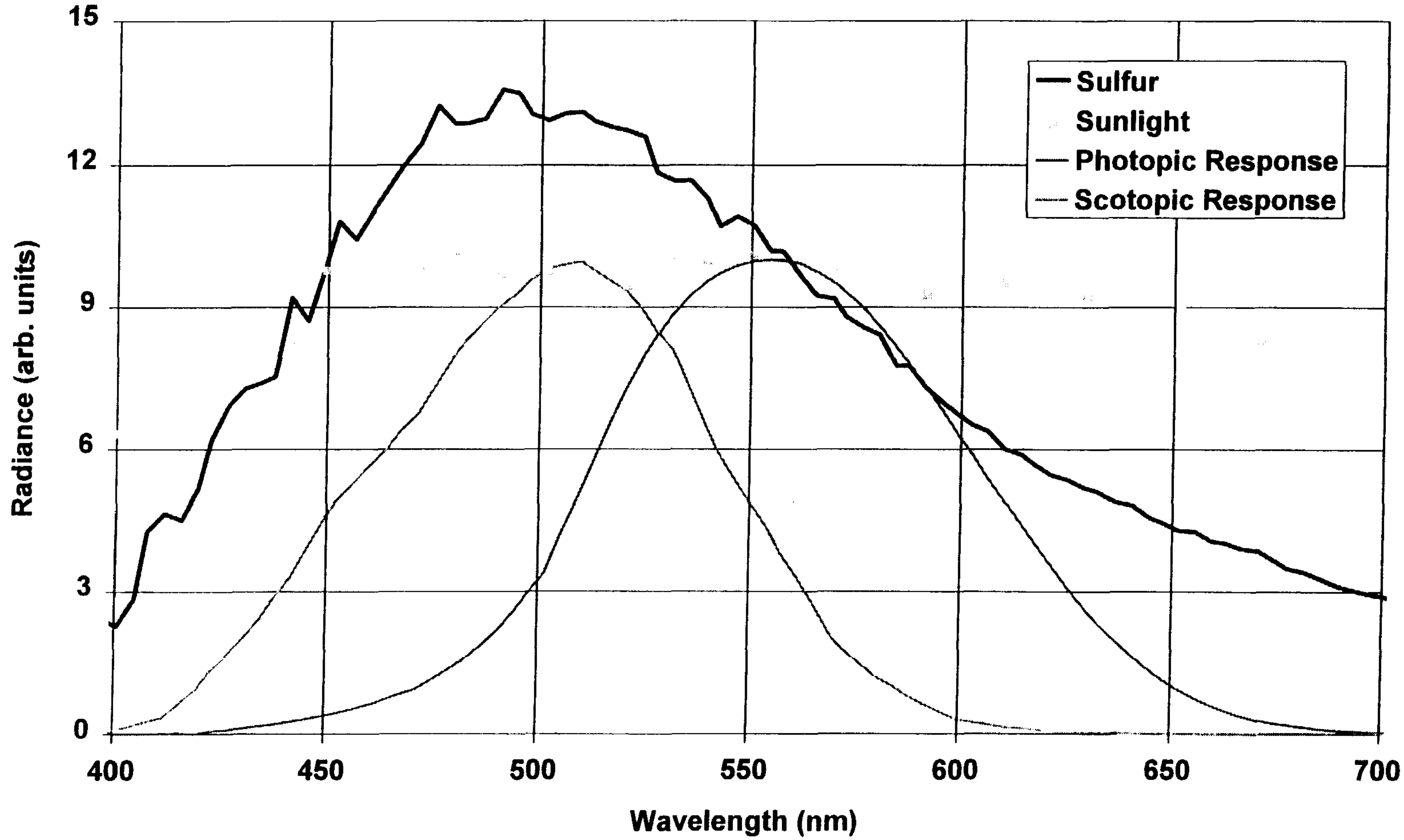
FusionLighting

Microwave Electrodeless Lamp



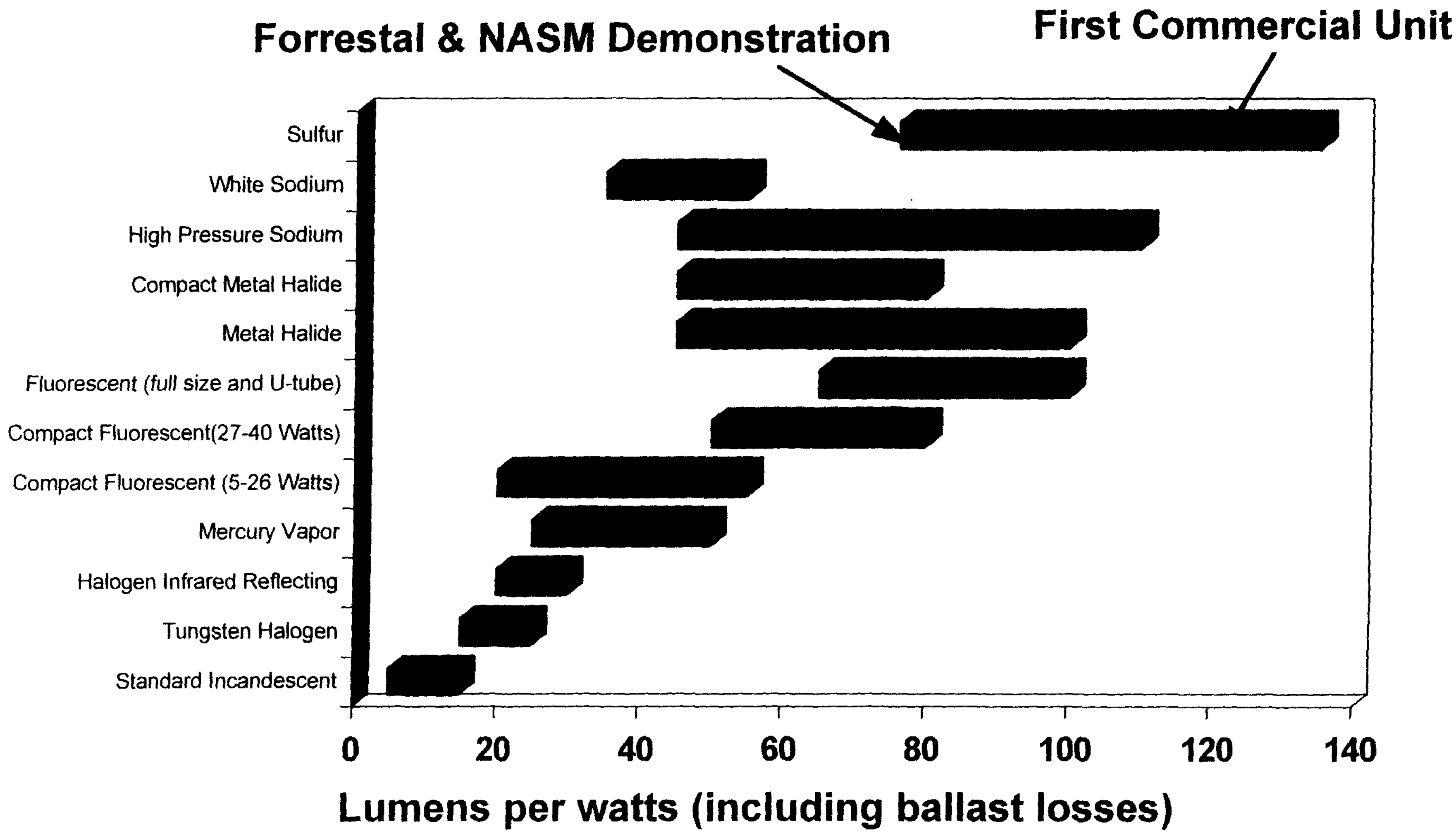
FusionLighting

Spectra



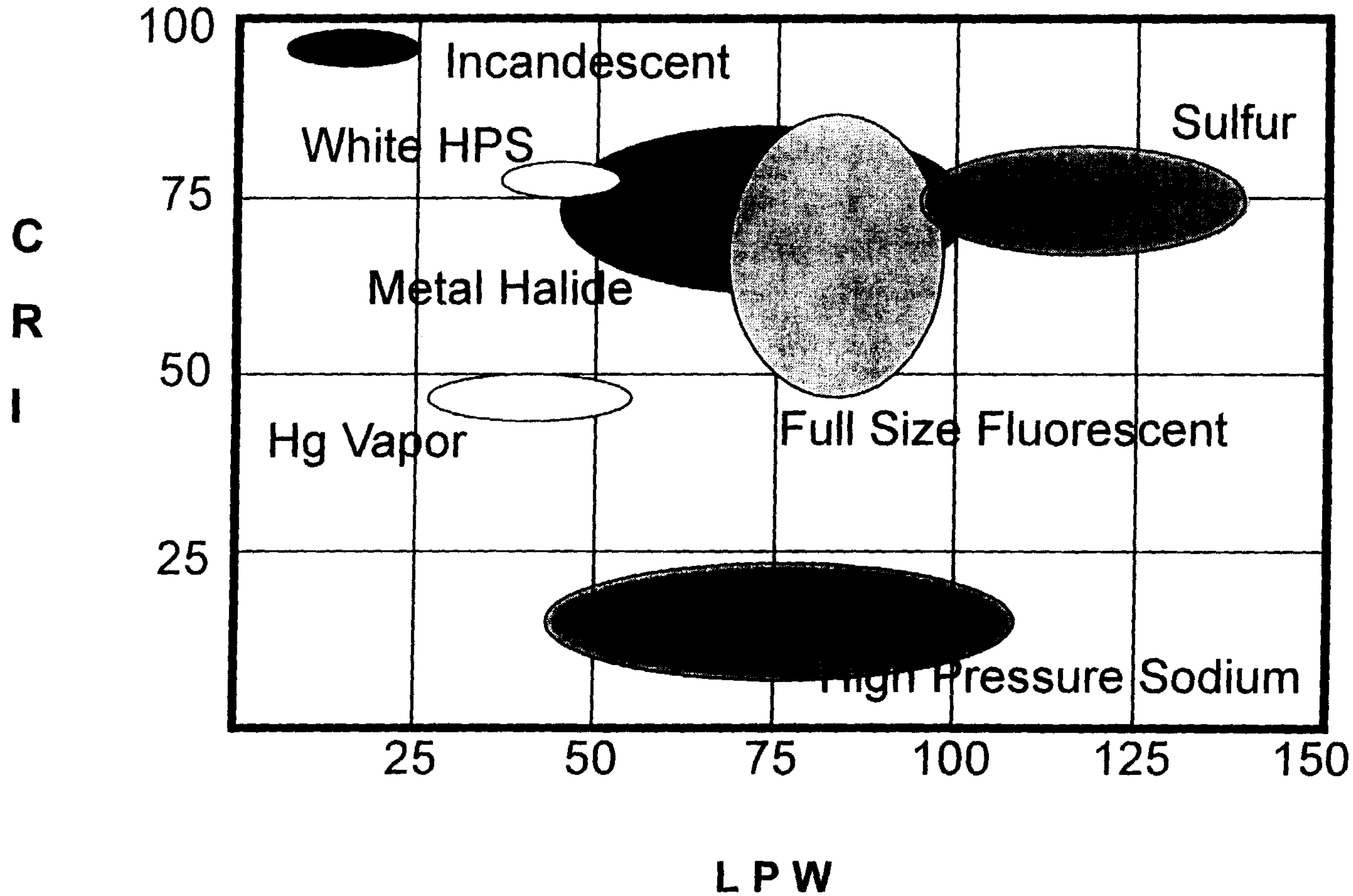
FusionLighting

Light Source Efficacies



FusionLighting

Lamp System Efficacies

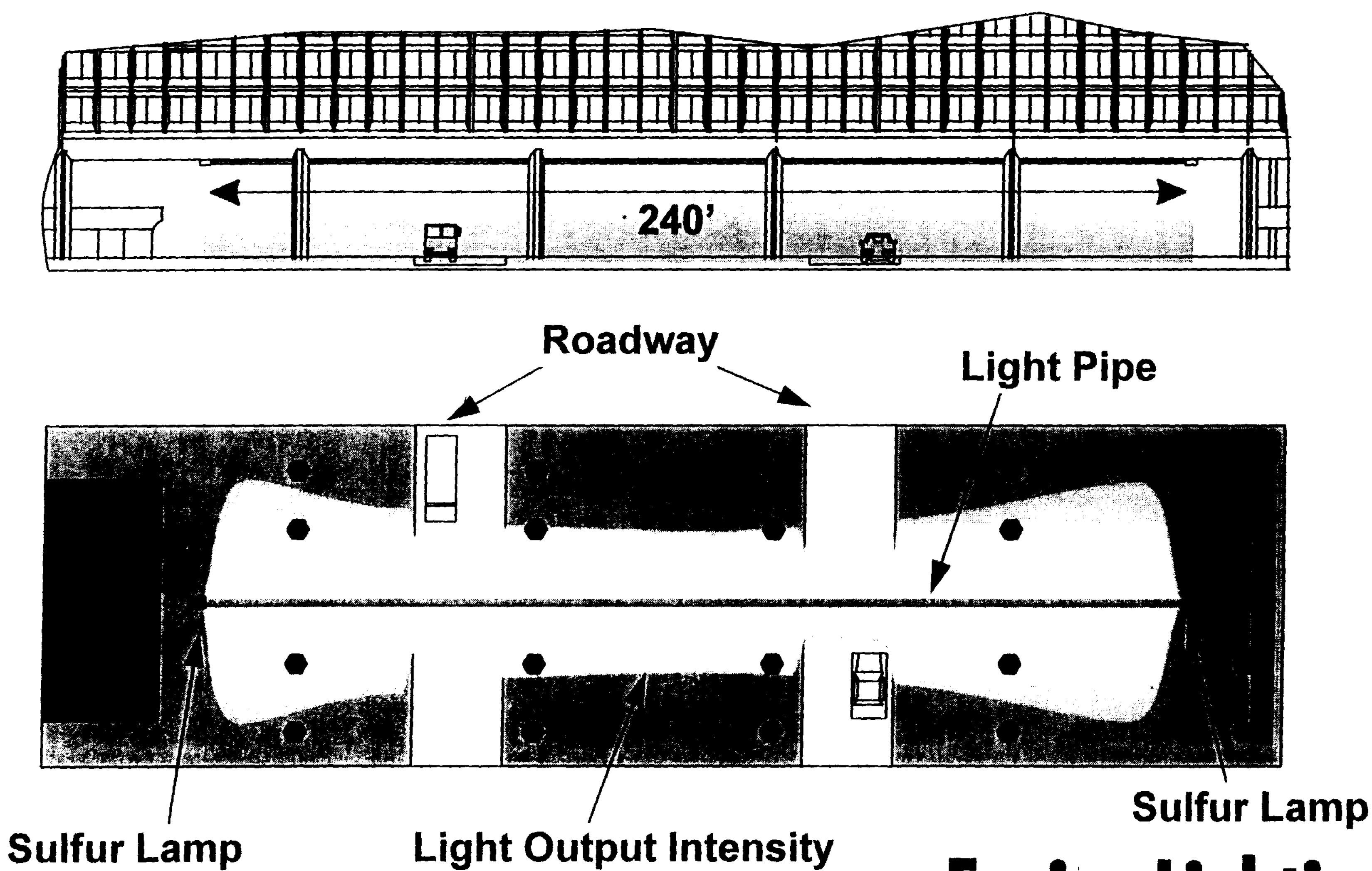


FusionLighting

US Departmental of Energy
Forrestal Building, Washington, D.C.

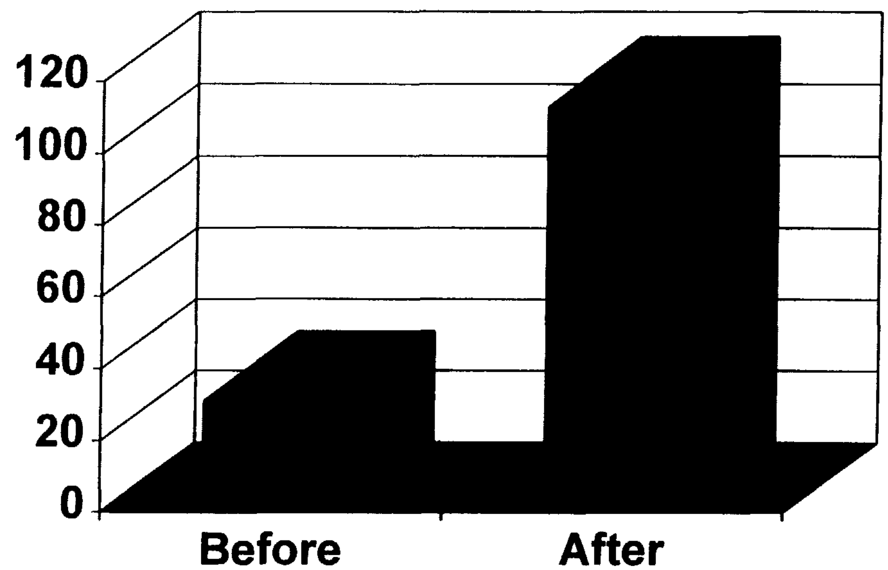
FusionLighting

Forrestal Building



FusionLighting

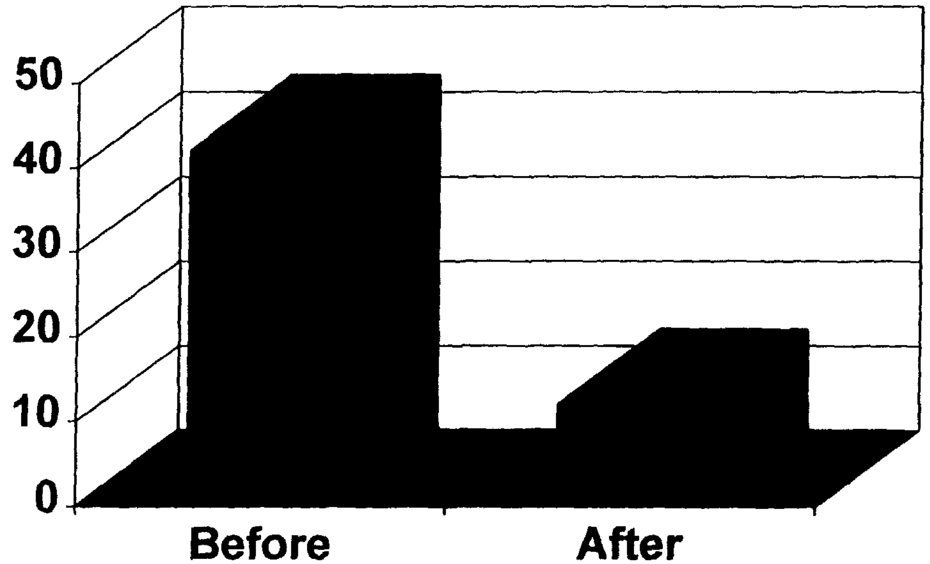
U.S. Department of Energy
Forrestal Building Light Intensity



The average light intensity values over space for the mercury lamps (Before) was 31 Lux compared with 113 Lux for the sulfur (After).

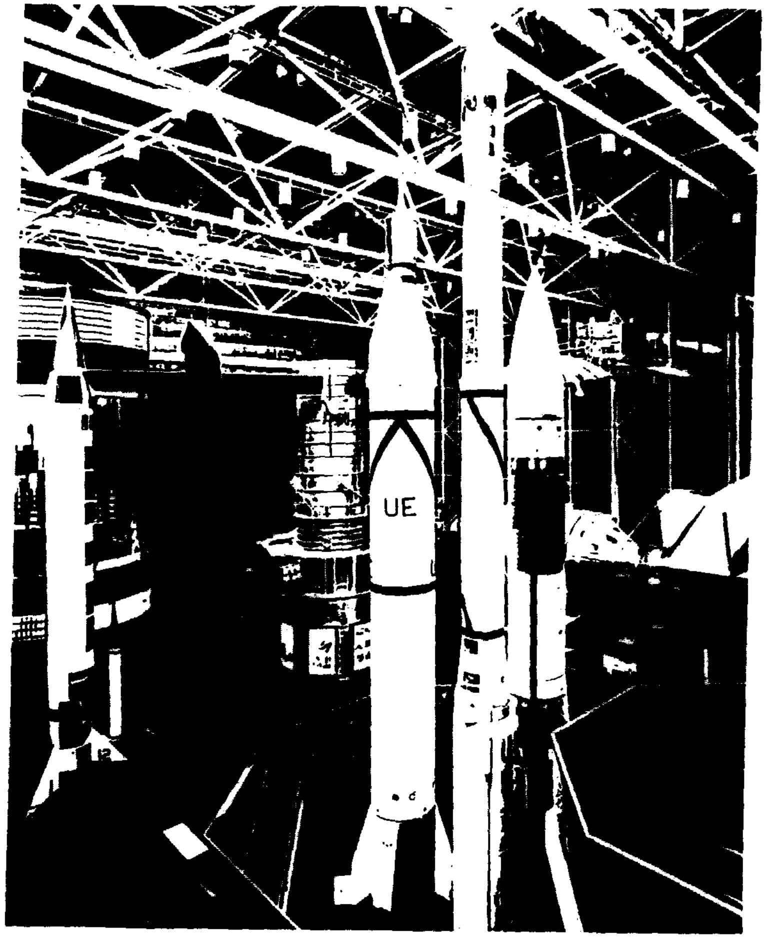
FusionLighting

U.S. Department of Energy Forrestal Building Energy Use



The total energy use for the mercury lamps (Before) was 42 K watts compared with 12 K watts for the sulfur (After).

National Air & Space Museum



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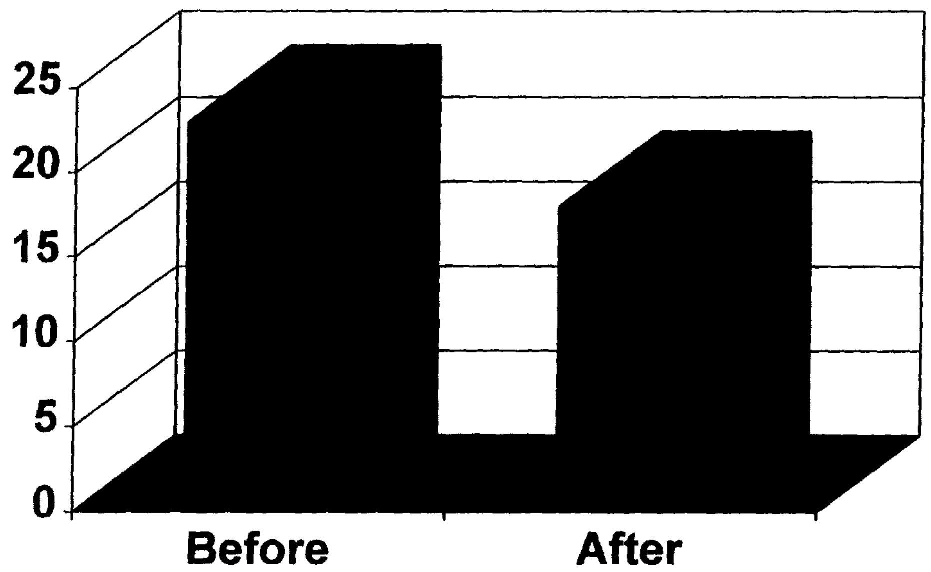
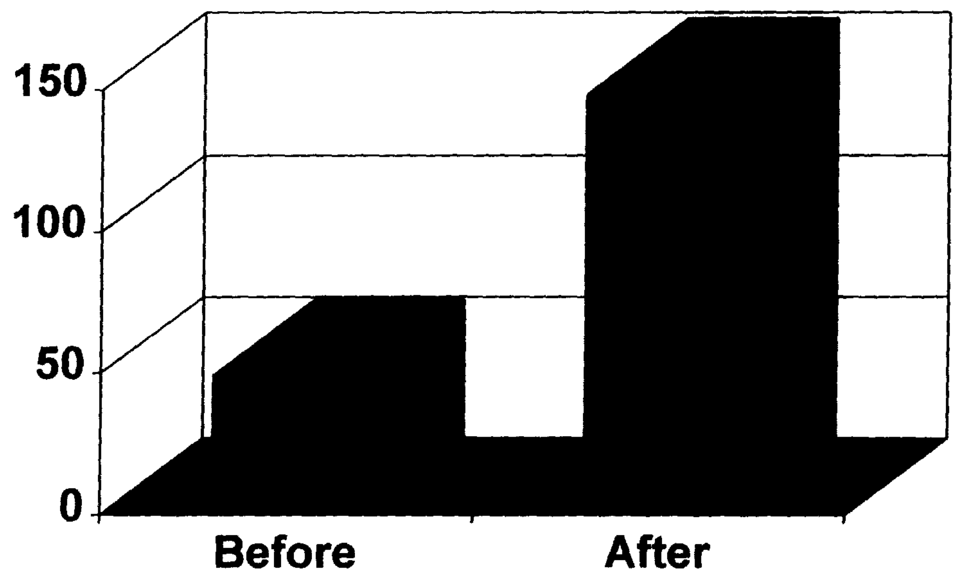
National Air & Space Museum Energy Use



The total energy use for the mercury lamps (Before) was 23 K watts compared with 18 K watts for the sulfur (After).

National Air & Space Museum
Light Intensity



The average light intensity values over space for the mercury lamps (Before) was 49 Lux compared with 148 Lux for the sulfur (After).

FusionLighting

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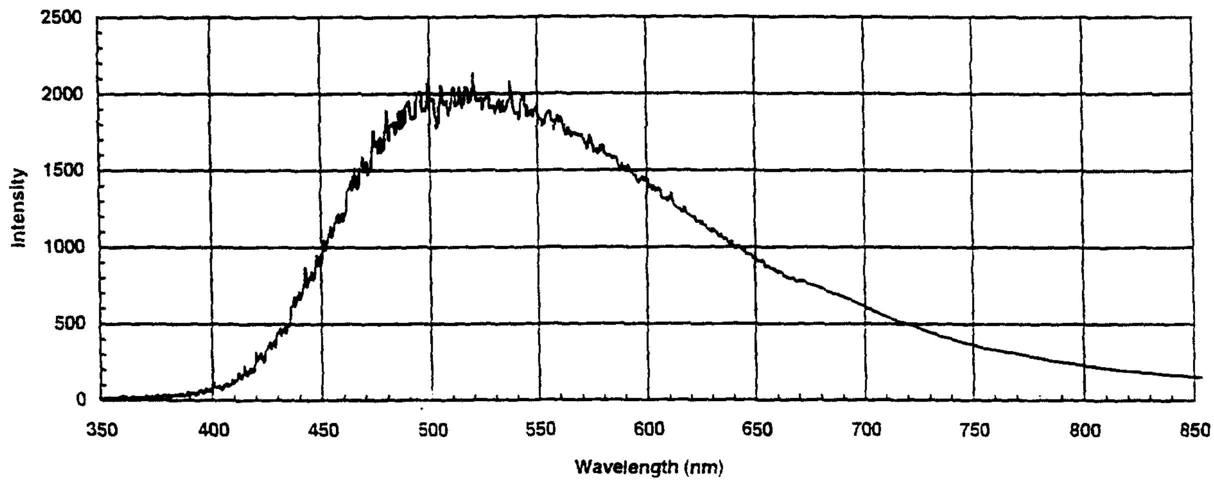
Solar 1000™ Specifications

Electrical	
Input voltage and frequency	1φ 200 V/230 V 50 Hz, 208 V/240 V 60 Hz
Input power	1375 W
Power factor	>.93
Environmental[1]	
Ambient operating temperature	*-20 to 60°C*
Relative humidity	*10% to 90% (Non condensing)*
Physical	
Lamp module mass	6 kg
Power supply mass	22 kg
Output	
Total luminous flux	130,000 lumens
Correlated color temperature	6000 °K
Color rendering index (R_a)	79
Average luminance	19 candela / mm^2
Flicker (max-min)/max	≤ 15%
x chromaticity coordinate	0.3171
y chromaticity coordinate	0.397
S/P ratio	2.4
Design Lifetime	
Lamp system excluding filter and magnetron	*45,000 hours*
Filter, magnetron	*15,000 hours*

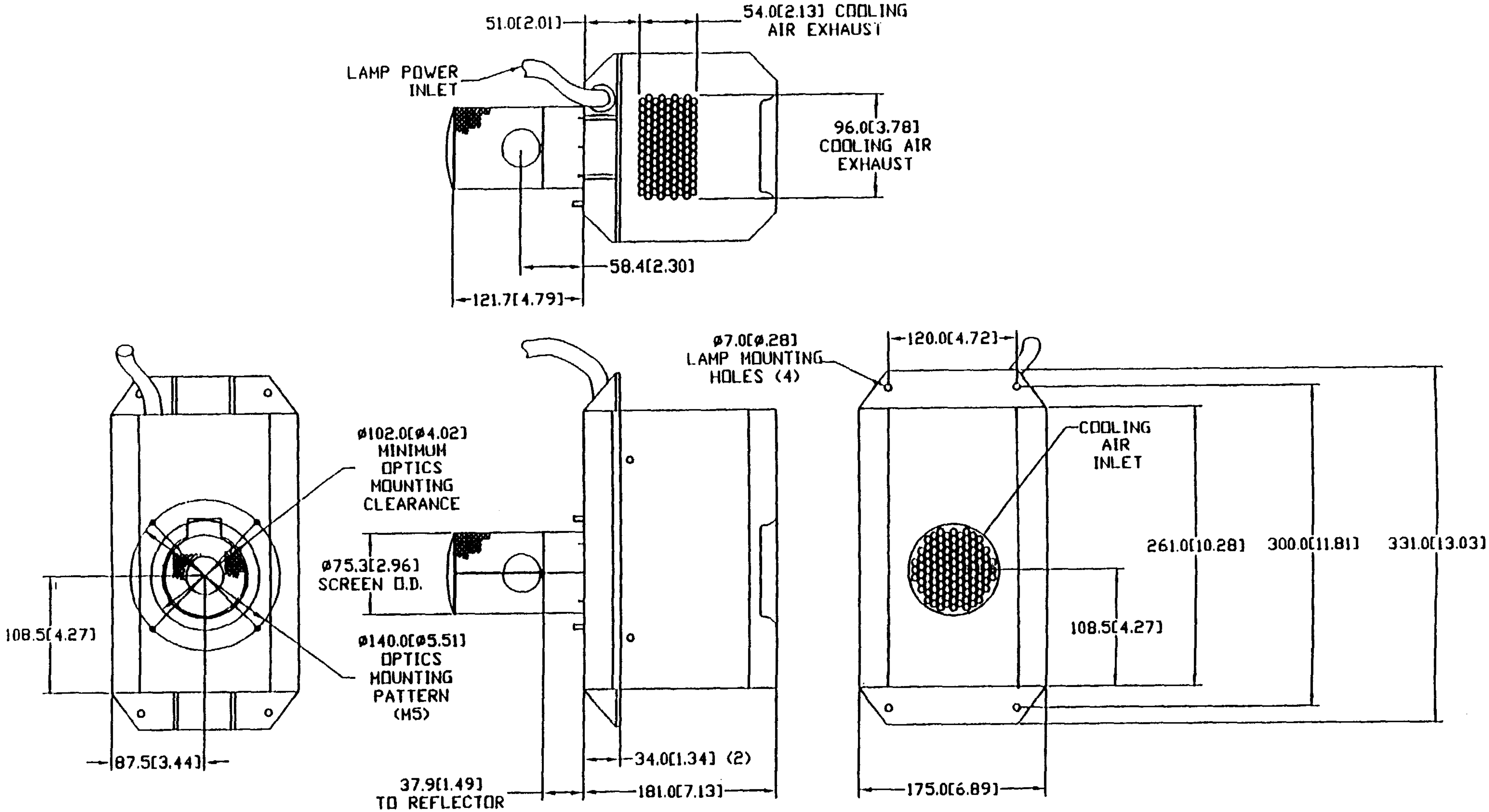
[1] This lamp is NOT intended for unprotected outdoor use or use in corrosive environments.

Typical Spectral Power Distribution of Solar 1000™



Allocation of Wattage over spectrum (Total power=474 Watts)

Wavelength (nm)	Color	Percentage of Output
<380	ultraviolet	0.14%
380-400	near violet	0.21%
400-435	violet	1.92%
435-495	blue	18.12%
495-565	green	30.08%
565-590	yellow	9.20%
590-625	orange	10.69%
625-700	red	14.56%
700-780	near red	7.08%
>780	infrared	8.0%



SOLAR 1000™ SAA

FusionLighting